AL. C. 1181261

A Study of Indoor Air Quality in Alberta Schools

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A STUDY OF
INDOOR AIR QUALITY
IN ALBERTA SCHOOLS

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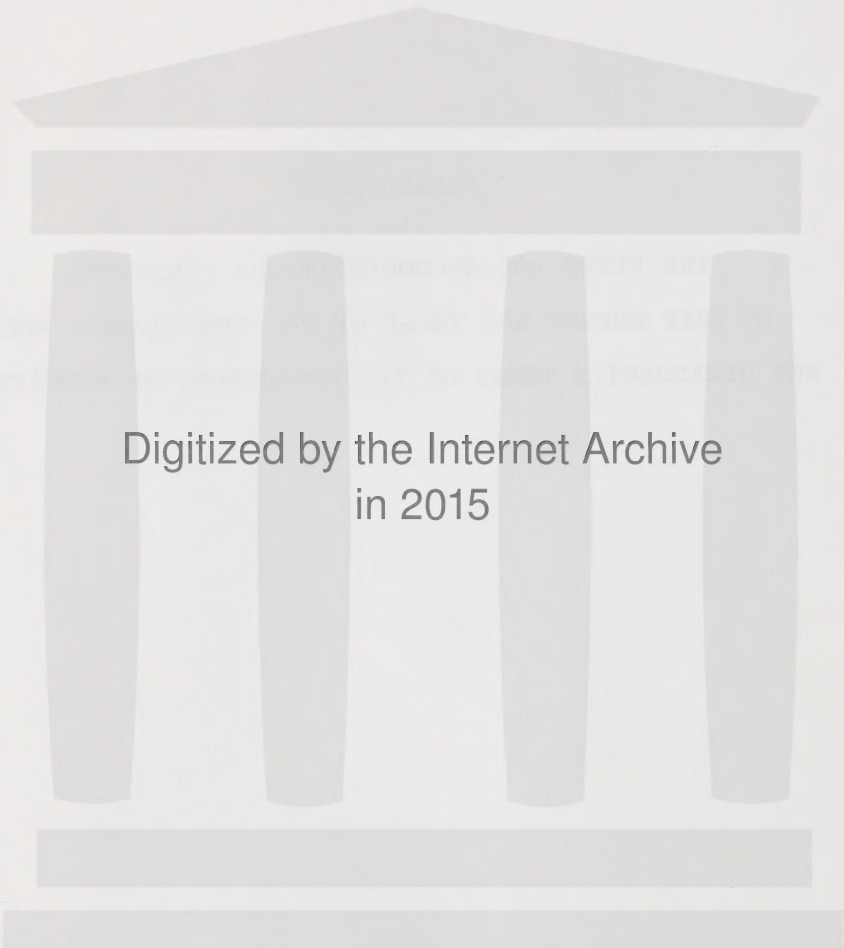
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A STUDY OF INDOOR AIR QUALITY IN ALBERTA SCHOOLS

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ACKNOWLEDGEMENTS

The study team members were Chris Collett of Theodore D. Sterling Limited and David Cousins, P.Eng. of Keen Engineering Co. Ltd.

The study team appreciates the assistance of the school principals, teachers, administrative and maintenance staff for their co-operation in filling out the questionnaires and for tolerating minor interruptions during the air quality testing.

The study team would like to thank Dr. Warren Hathaway for his assistance and guidance throughout this study, and to Rob Fiedler for his editorial assistance. The study was funded by Alberta Education.

A STUDY OF INDOOR AIR QUALITY IN ALBERTA SCHOOLS

EXECUTIVE SUMMARY

The purpose of this study was to investigate the indoor air quality in a number of classrooms and to establish correlations between the type of mechanical systems, the age of construction and the measured level of indoor air quality.

The building survey results combined with the occupant questionnaire results indicated that there may be problems in some schools.

Testing of air quality in the three schools selected for detailed study indicates carbon dioxide levels in portable classrooms were three times higher than recommended levels. This condition resulted when fans in furnaces were turned off due to high noise levels. The recommended levels were marginally exceeded in the "Old" school where the unit ventilator fans were turned off. All other measurements were acceptable except for relative humidity, which is a function of the dry Alberta climate.

All indoor air quality measurements in the "Renovated" school were acceptable except in a few classrooms. These particular rooms were having minor problems with air and water balancing. Maintenance staff were in the school on the day of the testing to work on these problems. The air quality in the "New" school was acceptable.

The indoor air quality in the schools tested generally is acceptable, although carbon dioxide levels were above normal in some instances.

AN INDOOR AIR QUALITY STUDY IN ALBERTA SCHOOLS

OVERVIEW

The purpose of this study was to investigate the indoor air quality in a number of classrooms and to establish a correlation between the type of mechanical systems, the age and type of construction and the measured level of indoor air quality.

Twelve schools representing samples of New schools, Old schools and recently Renovated schools were included in the first phase of this study. In this phase both the teachers perceptions of indoor air quality and their own health symptoms were examined together with the actual building plans. From the sample of schools, one school from each of the three categories (New, Old and Renovated) was selected for detailed air quality measurement; each of the schools representing the worst case in its category.

The second phase of the study entailed collection of air samples and measurement of: carbon dioxide (CO_2) levels, carbon monoxide (CO) levels, air temperature, air humidity, respirable particulates, and the total fungi and bacterial count.

When the results of the air sample analyses were compared to acceptable standards, it was found that the air quality in the schools was acceptable in all cases except for a sample of portables which had self-contained heating and ventilation units (furnaces). Because these units were operated intermittently (i.e., only when heating), carbon dioxide accumulated to levels above accepted standards during the late morning and the afternoon. Although the levels were about three times greater than accepted standards for comfort, they were not at a level which posed a significant health hazard.

The results of the study, while indicating that air quality in schools is generally quite good, also indicates that attention should be paid to adequate ventilation. This is especially the case in newer schools that tend to be of tighter construction and where the volume of outdoor air may have been reduced.

AN INDOOR AIR QUALITY STUDY IN ALBERTA SCHOOLS

PURPOSE OF THE STUDY

The purpose of this study was to investigate:

.1 The heating and ventilation systems;
.2 environmental conditions;
.3 health related symptoms of the occupants, and;
.4 measurement of indoor air quality parameters of selected schools.

Findings were compared based on the age of construction and type of ventilation system installed in the school.

METHODOLOGY

The methodology for this study was based on the "Five-Phased Strategy for Diagnosing Air Quality and Related Ventilation Problems in Commercial/ Large Buildings" developed by Theodore D. Sterling Limited (Sterling, 1987). This survey has been used extensively across North America and the United Kingdom and large statistical base exists for comparitive purposes.

Twelve school buildings representing specific age groups and types of mechanical systems were chosen for the study. In order to obtain a better understanding of the effectiveness of the "ventilation system", the types of schools and mechanical systems chosen are typical of many schools in the province of Alberta.

Twelve schools representing the following three school types were selected and investigated in the early part of the study:

OLD	No modifications to heating and ventilation systems. Construction was prior to 1960.
RENOVATED	Construction took place prior to 1960 but the ventilation system has been upgraded to meet current building codes.
NEW	Construction took place during the past 15 years.

Phase One

Phase One was carried out on all twelve schools and consisted of a review of each building's architectural and mechanical systems design and maintenance practices.

The major architectural components of the buildings were reviewed and identified. The age of construction was identified and the type of interior finish, floor covering, type of windows were examined for sources of indoor air contaminates.

The heating and ventilation system was reviewed in detail. The method of delivering supply air to, and removing return and exhaust air from a typical classroom was reviewed. The location of the outdoor air intake was identified as well as the location of the discharge from return and exhaust fans.

Phase Two

Phase Two, also carried out on all twelve schools, consisted of administoring a "Work Environment Survey" questionnaire to all building occupants (teachers, administrators and custodial personnel, but not students) to discover the environmental comfort problems and health related symptoms experienced by the building occupants.

The Work Environment Survey is a self administered, machine readable questionnaire which has been previously used to survey occupant perceptions of environmental conditions and health symptoms in office buildings. The questionnaire has been administered to 2,454 office workers in Canada and the United Kingdom.

The questionnaire is designed to obtain three catagories of information:

1. Demographic and occupational characteristics of the building occupants, for example, age, sex, educational background and job type. For the purposes of this study, this information was already known.

2. Occupant perceptions of satisfaction and dissatisfaction with indoor environmental conditions, including air movement, humidity, temperature, lighting and noise conditions.

3. Occupant perceptions about health-related symptoms. The health symptoms are divided into three general groups, two directly related to air quality and the third not directly related to air quality. The first group includes symptoms of respiratory, mucous membrane or skin irritation. The second group consists of symptoms of "building illness", such as headache, fatigue and sleepiness. These first two groups have been commonly identified in "sick buildings" and have been related to air quality. The third group consists of symptoms which have not been directly linked to air quality conditions, such as neckache, backache or tension. These systems have been linked to stress in the workplace.

The Work Environment Survey is designed to determine the frequency of each health and comfort factor using a four point scale of "never", "rarely", "sometimes", or "always". For the purposes of data analysis, the "never and "rarely" responses are combined into one category and the "sometimes" and "always" is used in the data analysis to indicate the prevalence rate of health and comfort problems.

Based on the results of Phase One and Phase Two, three schools were chosen, (one each from the Old, Renovated and New categories) for continued testing in Phase Three.

Phase Three

Phase Three entailed collection of information about air quality and it was carried out in three schools, an old school, a renovated school and a new school. Measurements were taken at selected sampling sites inside the school building. A sample was also measured outside to determine the ambient condition of the outdoor air.

The following selected indoor air quality parameters were measured in each school:

i) Carbon Dioxide - CO_2 as an indicator of the buildup contaminants generated indoors. This was measured using Gastec, hand aspirated, direct reading detector tubes.

The ASHRAE guideline for CO_2 for adequate ventilation is a concentration of less than 1,000 ppm (ASHRAE, 1988).

Research by the Ontario Ministry of Labour has suggested that ideally CO_2 concentrations should be controlled to below 600 ppm to maximize occupant comfort (Rajhans, 1983). At CO_2 concentrations between 600 and 1,000 ppm, occupant complaints of headache, fatigue and stuffiness become more prevalent. At concentrations above 1,000 ppm, these complaints may frequently be reported by many building occupants.

ii) Carbon Monoxide - CO as an indicator of combustion byproducts infiltrating from outside the building or from gas fired appliances. This was measured using Nova 310L Electrochemical Analyzer.

Health and Welfare Canada have developed a maximum acceptable residential exposure guideline of less than 25 ppm of CO for a one hour average, and less than 11 ppm for an eight hour average (HWC, 1987).

The industrial standard exposure guideline of 50 ppm for an eight hour average. This was developed by th American Conference of Governmental Industrial Hygienists and has been adopted by many provincial government agencies.

iii) Temperature and Relative Humidity are indicators of occupant thermal comfort condition. These parameters were measured using a Viasala HMI-31 Indicator and Probe.

ASHRAE standard 55-1981 defines comfort ranges for indoor temperatures. In general acceptable ranges are 19 to 24.5^{o}C in winter and 22 to 26.5^{o}C in the summer. Because the testing for this study was carried out in March, the test measurements will be compared to the winter range.

ASHRAE 55-1981 defines a relative humidity comfort zone that ranges between 20% and 80% (ASHRAE, 1981).

iv) Respirable Particulates, (RSP), as defined as being small enough to be respirable (less than 5 microns in diameter). They are an indicator of ventilation filtration system efficiency and of problems related to smoking This parameter was measured using a Shibata P-5 Digital Dust Indicator.

Health and Welfare Canada have developed a residential guideline exposure level for particulate matter of 100 micrograms per cubic metre (ug/m3) for an eight hour average (HWC, 1987).

v) Total Fungi and Bacteria Count represents indicators of airborne microbial load. Samples were collected on petri dishes containing nutrient agar using an Anderson Sampler (Morey, 1986).

A microbial concentration level of over 1,000 colony forming units per cubic metre (cfu/m3) indicate possible problems which warrant further investigation.

In an industrial environment, the recommended level of concern is at concentrations of greater than 10,000 cfu/m3 (Morey et al 1984).

Two sets of measurements for CO_2, CO, temperature, relative humidity and RSP were taken at each sampling site in each of the three schools. One set of measurements was taken during the morning and a second set of measurements during the afternoon. The total fungi and bacteria were measured at least one indoor site and one outdoor site at each school.

RESULTS SUMMARY - OLD SCHOOL

The sections of this school considered for the study were constructed in 1949, 1950 and 1954. The school is of wood frame construction with a crawl space and built up flat roof.

The heating is provided by two steam boilers and is distributed to perimeter radiation and unit ventilators in each classroom. Each classroom has a thermostat.

The ventilation is provided by operable windows and unit ventilators with general exhaust fans located in the corridor cloak rooms. The exhaust fans and unit ventilators were not operating at the time of the test. The teachers have found that the unit ventilators are too noisy to run continuously and they only operate them in the coldest weather. There is no humidification system.

This school had a teacher's smoking room. Some measurements were taken in this room for comparison purposes.

ENVIRONMENTAL CONDITIONS

The occupants of this old school reported a higher prevalence of complaints of indoor environmental conditions than the other Old schools of the test sample. The most common complaints were too little air movement (79.4%), air too dry (94.1%), too hot (91.1%), too cold (76.4%), just right (26.4%), unpleasant odours (82.3%) and too noisy (85.2%). The lighting levels were satisfactory.

HEALTH SYMPTOMS

The occupants of this school reported the highest prevalence rate for 19 of 22 symptoms found in the sample of Old schools. The most commonly reported symptoms were headache (70.5%), fatigue (85.2%), sore throat (79.4%) and nose irritation (70.5%). The occupants of this school also reported a higher prevalence of non-air quality related symptoms (e.g., neckache, backache) which may indicate a higher degree of perceived stress in the work-place. The response of this school was 61.7% reporting that they experience tension in the work-place compared to a range of 5.3% to 32.2% for other Old schools of the test sample.

INDOOR AIR QUALITY MEASUREMENTS

The CO_2 levels in the classrooms ranged from 750 to 1,100 ppm in the morning and from 900 to 1,200 ppm in the afternoon. The office and staff room CO_2 levels ranged from 550 to 700 ppm. The concentrations in the teacher's smoking room ranged from 900 to 1000 ppm. The outdoor concentration ranged from 350 to 400 ppm.

The CO levels ranged from 1.2 to 1.9 ppm in the teaching areas of the school. The concentrations in the teacher's smoking area ranged from 3.5 to 4.8 ppm. The outdoor concentrations ranged from 2.0 to 2.2 ppm.

The temperature in the classrooms ranged from 21.6 to 22.8^{o}C in the morning and ranged from 22.5 to 23.6 in the afternoon. The relative humidity ranged from 12.5 to 17.8%. The outdoor temperature ranged from 6.3 to 10.9^{o}C and the relative humidity ranged from 28.5 % to 18.6 %.

The respirable particles ranged from 11 to 24 ug/m3 in the academic areas. The sample taken in the teacher's smoking room had a concentration that ranged from 142 to 396 ug/m3. The sample taken outdoors ranged from 20 to 23 ug/m3.

The bacteria count inside the school ranged from 230 to 489 cfu/m3. The bacteria count outside the school was 486 cfu/m3. The fungi count ranged from 89 to 268 cfu/m3 inside the school and was 150 cfu/m3 outside the school.

OBSERVATIONS

All of the indoor air quality measurements fall into the acceptable range except for the CO_2. It appears that the ventilation system is not bringing in enough outdoor air to remove the CO_2 build up. The indoor air quality measurements in the teacher's smoking room were significantly higher than the rest of the school, but still within the guidelines.

RECOMMENDATIONS

It is recommended that:

Outdoor air dampers on the unit ventilators be overhauled and the exhaust fan be operated in conjunction with unit ventilators.

Consideration be given to the complete redesign of the heating and ventilation system due the age and general condition of the steam heating system and the unavailability of parts for the unit ventilators.

Consideration be given to additional means of humidification in ventilation system redesign.

RESULTS SUMMARY - RENOVATED SCHOOL

The original building was constructed in 1953 with sections added in 1956, 1957, and 1960. The final section was added in 1985 at which time the whole school was completely modernized. The school is a combination of wood frame and masonry construction with slab on grade.

The heating is provided by two hot water boilers and distributed by wall fin radiation located on the exterior walls behind an architectural millwork enclosure.

Ventilation is provided by four air handling units that supply the classrooms, adminstration and library. The industrial arts area has separate units for dust collection, exhaust and make-up air. The air is distributed via under-slab ductwork that was reused in the renovated areas. The distribution is overhead in the gym, library and ancillary classroom. Pan humidifiers are provided for each air handling unit.

ENVIRONMENTAL CONDITIONS

The occupants of the renovated school complained of too little air movement (70.6%), air too dry (73.7%), too stuffy (88.2%), too hot (73.7%) and too cold (73.3%). Most felt that the lighting and noise levels were just right and that there were few reported problems of odours.

HEALTH SYMPTOMS

The occupants reported the highest prevalence rate for 17 of 22 symptoms found in the sample of Renovated schools. The most commonly reported symptoms were headache (64.7%), fatigue (73.7%), cold/flu (58.8%), sore throat (47.1) and nose irritation (70.5%). All schools in this category reported about the same level of non-air quality related symptoms (e.g., neckache, backache). The response in the renovated school was 58.8% reporting that they experience tension in the work-place compared to a range of 14.2% to 37.0% for other Renovated schools.

INDOOR AIR QUALITY MEASUREMENTS

The CO_2 levels ranged from 600 to 750 ppm in most of the classroom areas, adminstration, library and gymnasium. Three classrooms on the west side had concentrations that ranged from 950 to 1,400 ppm. The outdoor concentration was 400 ppm.

The CO levels ranged from 0.7 to 1.4 ppm throughout all the test areas inside the school. The outdoor concentration ranged from 1.1 to 1.4 ppm.

The temperature in the classrooms ranged from 21.8 to 24.8^{o}C in the morning and ranged from 22.4 to 24.2^{o}C in the afternoon. The relative humidity ranged from 10.0 to 18.0%. The outdoor temperature ranged from 1.1 to 5.6^{o}C and the relative humidity ranged from 45.2 % to 35.0 %.

The respirable particles ranged from 10 to 20 ug/m3. The concentration of respirable particles outdoors was 11 ug/m3.

The bacteria count (cfu/m3 - Colony Forming Units per cubic metre) inside the school ranged from 129 to 145 cfu/m3. The bacteria count outside the school was 202 cfu/m3. The fungi count ranged from 55 to 141 cfu/m3 inside the school and was 78 cfu/m3 outside the school.

OBSERVATIONS

All indoor air quality measurements fall into the acceptable category except for CO_2 readings in the three classrooms on the west side of the school. The air is delivered to these rooms by ductwork in the slab. The supply registers are located about 800 mm from the wall due to structural reasons, and this location appears to have caused drafts. To reduce the effect of the drafts, balancing dampers have been closed off so that only about 20% of the design air flow rate is reaching the room.

RECOMMENDATIONS

It is recommended that practical ways be studied to reduce drafts such as:

The relocation of the supply air registers closer to the wall. This would allow allow the ventilation air to blow through the radiation cabinet.

The provision of a register that can direct the ventilation air towards the wall.

The reduction of the total air flow (and therefore the velocity) to the room, but keeping the amount of outdoor air constant. For example, reduce total flow rate from 1,000 cfm and 200 cfm of outdoor air to 500 cfm and 200 cfm of outdoor air). The outdoor air quantity, and therefore the energy costs, would stay the same.

RESULTS SUMMARY - NEW SCHOOL

This school was constructed in 1980 and is of masonry, slab on grade construction. There are six wood frame portable classrooms attached to the school.

The main school is heated by two hot water boilers that serve the perimeter radiation. There is a thermostat in each classroom. The interior zones have re-heat coils in the ventilation system.

Ventilation is provided to the classrooms by a central ventilation unit with overhead distribution. The gymnasium and lunch-study each have their own ventilation units. Steam humidification is provided to each air handling system, but the steam boiler was not working on the day of the test. The portable classrooms are heated and ventilated by a furnace located in each classroom. The furnace fans were set in the intermittent mode and would only run when the furnace was providing for heat (not in continuous mode operation). No humidification is provided to the portable classrooms.

ENVIRONMENTAL CONDITIONS

The occupants complained of too little air movement (73.7%), air too dry (100%), too stuffy (84.2%), too hot (68.4%) and too cold (57.2%). Most felt that the lighting and noise levels were just right and that there were few reported problems of odours.

HEALTH SYMPTOMS

The occupants reported the highest prevalence rate for 11 of 22 symptoms found in the sample of New schools. The most commonly reported symptoms were headache (78.4%), fatigue (78.4%), sleepiness (68.4%), sore throat (73.7%) and nose irritation (52.6%). This school had a slightly higher incidence of non-air quality related symptoms (e.g., neckache, backache). The response of this New school was 47.4% reporting that they experience tension in the work-place compared to a range of 21.0% to 50.0% for other New schools.

INDOOR AIR QUALITY MEASUREMENTS

The CO_2 levels ranged from 600 to 900 ppm in most of the classroom areas, administration, library and gymnasium. The six portable classrooms had concentrations that ranged from 1,000 to 2,800 ppm. The outdoor CO_2 concentration was 400 ppm.

The CO levels ranged from 0.6 to 1.0 ppm throughout all the test areas in the school. The outdoor concentration ranged from 1.0 to 1.1 ppm.

The temperature in the classrooms ranged from 22.3 to 23.8 deg C in the morning and ranged from 22.8 to 24.0 deg C in the afternoon. The relative humidity ranged from 15.8 to 20.3 % in the main school and as high as 24.1% in the portable classrooms. The outdoor temperature ranged from 4.8 to 8.7 deg C and the relative humidity ranged from 48.3 % to 33.0 %.

The respirable particles ranged from 11 to 20 ug/m3 in the school. The outdoor concentration ranged from 12 to 13 ug/m3.

The bacteria count (cfu/m3 - Colony Forming Units per cubic metre) inside the school ranged was 388 cfu/m3. The bacteria count outside the school was 106 cfu/m3. The fungi count ranged was 56 cfu/m3 inside the school and was 51 cfu/m3 outside the school.

OBSERVATIONS

All indoor air quality measurements fall into the acceptable category except for CO_2 readings in the six portable classrooms. These readings are almost three times the acceptable standards of 1,000 ppm.

It appears that the teachers in the portable classrooms run the furnace fan intermittently because too much noise is generated and it interferes with the teaching environment. The portable classroom furnace ventilation unit has an outdoor air damper to provide outdoor air to the unit, but will only do so when the fan is operating. The result is that the amount of outdoor air introduced into the classroom could be less on a warmer day than on a colder day.

The steam boiler, the source of humidification for the air handling systems in the main school, was not operating due to a maintenance problem.

RECOMMENDATIONS

It is recommended that:

The circulation fan in the portable furnace run continuously when the class is in operation. Modifications are required for the ductwork and acoustical treatment to reduce noise levels.

The steam humidification boiler serving the central ventilation units, be put back into operation as soon as possible.

GENERAL SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Generally speaking, the air quality in the sample of schools included in this study is acceptable. The exceptions lie with the old school and with the portables where it was found that carbon dioxide build-up exceed recommended limits.

For each of the schools included in the study, specific recommendations are offered in order to bring air quality up to an acceptable standard.

Based on the findings of high levels of carbon dioxide in portable classrooms, we would recommend two plans of action. The first is to measure air quality and noise levels in the portable classrooms of three more schools. If it proves portables do contain high levels of carbon dioxide, then the second plan of action would be to develop alternative designs for portable heating and ventilation systems with the view to accepting one or more satisfactory designs as a standard for future portable classrooms.

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APPENDIX A

TABLES

TABLE 1

RESPONSES TO ENVIRONMENTAL QUESTIONS
(percentage "Sometimes" or "Always")

	OLD		RENOVATED		NEW	
	Selected School Results	Average Sample	Selected School Results	Average of Sample	Selected School Results	Average of Sample
Too Little Air	79.4	61.9	70.6	63.8	73.7	75.3
Too Stuffy	91.1	65.1	88.2	70.7	84.2	86.3
Too Dry	94.1	84.9	73.7	77.6	100.0	93.8
Too Hot	91.1	73.8	73.7	74.1	68.4	85.6
Too Cold	76.4	64.3	73.3	58.6	57.2	74.0
Unpleasant Odours	82.3	55.6	35.3	36.2	31.6	58.9
Too Noisy	85.2	69.0	47.1	65.5	89.5	66.4

TABLE 2

RESPONSES TO HEALTH RELATED QUESTIONS
(percentage "Sometimes" or "Always")

	OLD		RENOVATED		NEW	
	Selected School Results	Average Sample	Selected School Results	Average of Sample	Selected School Results	Average of Sample
Air Quality Related						
Headache	70.5	54.0	64.7	46.6	78.4	71.2
Fatigue	85.2	73.8	73.7	26.0	78.4	78.1
Cold/Flu	67.6	53.2	58.8	41.4	47.4	52.1
Sore Throat	79.4	46.0	47.1	39.7	73.7	60.9
Irritated Nose	70.5	56.2	70.5	32.8	52.6	44.4
Sleepiness	70.5	47.6	58.8	43.1	68.4	62.3
Non Air Quality Related						
Neckache	58.8	28.6	35.3	32.8	63.2	46.6
Backache	61.7	38.9	47.1	41.4	47.4	41.1
Tension	61.7	40.5	58.8	41.4	47.4	47.3
Depression	38.2	38.9	35.3	41.4	26.3	41.1

TABLE 3

RESULTS OF AIR QUALITY MEASUREMENTS

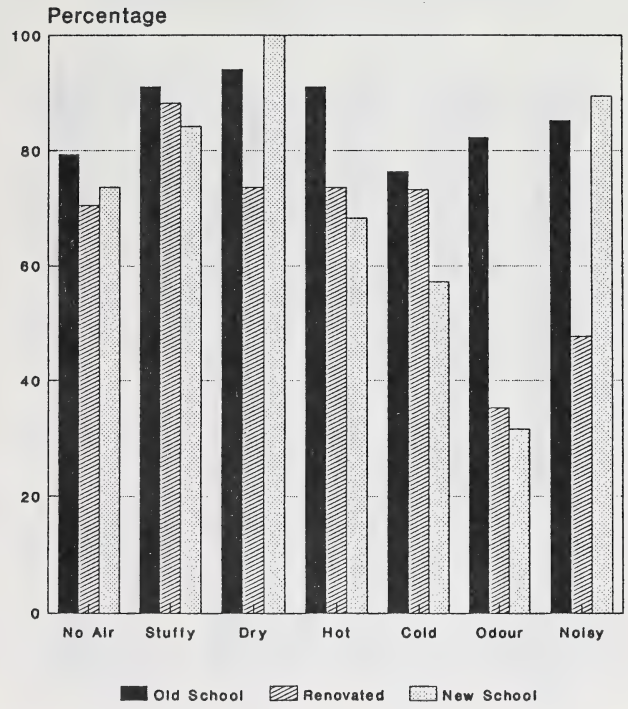
		Standard	Old School	Renovated School	New School	Portables
CO_2 (PPM)	AM	< 1,000	750	600	600	1,000
	PM		1,100	750	900	2,800
	OUT		350	400	400	
CO (PPM)	AM	< 11	1.2	0.7	0.6	0.9
	PM		1.9	1.4	1.0	1.0
	OUT		2.0	1.5	1.1	
Temperature (Degrees C)	AM	22-26.5	21.6	21.8	22.3	23.4
	PM		23.6	24.8	24.0	24.1
	OUT		10.9	5.8	8.7	
Relative Humidity	AM	20%-80%	12.5	10.0	15.8	24.1
	PM		17.8	20.0	20.3	31.2
	OUT		18.6	35.0	33.0	
Respirable Particles (ug/m3)	IN	< 100	14	10	10	15
	OUT		23	11	14	
Bacteria (cfu/m3)	IN	< 1,000	489	145	56	
	OUT		486	202	78	
Fungi (cfu/m3)	IN	< 1,000	268	141	388	
	OUT		150	78	51	

Note: - Time and place of observations:
- IN refers to indoor measurement.
- AM or PM refers to indoor measurements in the mornings or afternoon.
- OUT refers to outdoor measurements in the afternoon.

APPENDIX B

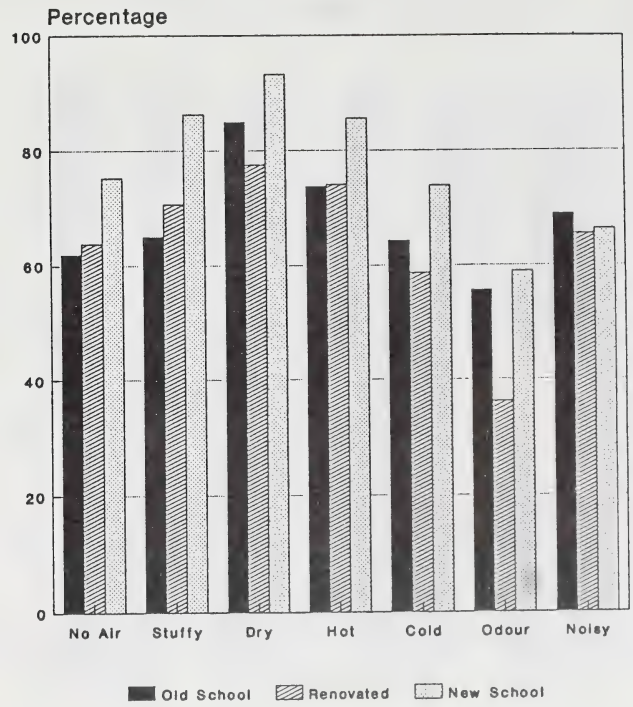
GRAPHS

Work Environment Survey Results
AIR QUALITY RELATED QUESTIONS
SPECIFIC SCHOOL RESPONSES



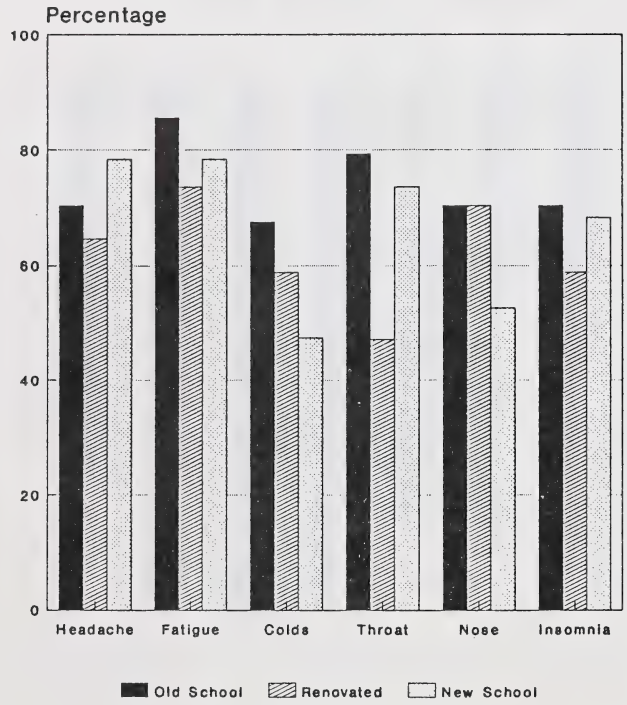
Graph No. 1

Work Environment Survey Results
AIR QUALITY RELATED QUESTIONS
AVERAGE OF SAMPLE



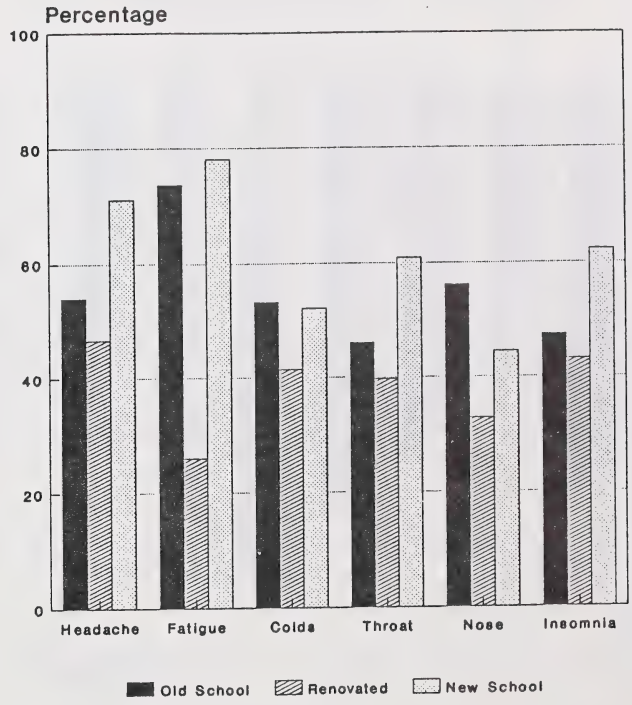
Graph No. 2

Work Environment Survey Results
AIR QUALITY RELATED HEALTH QUESTIONS
SPECIFIC SCHOOL RESPONSES



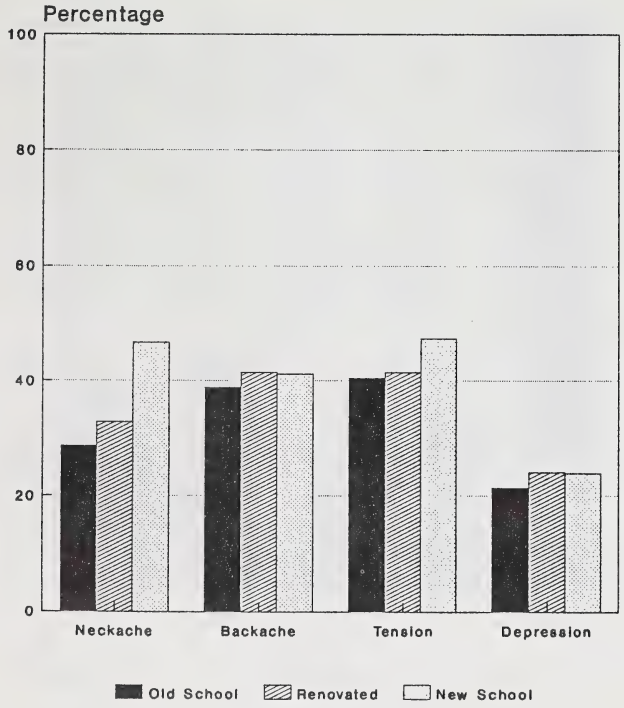
Graph No. 3

Work Environment Survey Results
AIR QUALITY RELATED HEALTH QUESTIONS
AVERAGE OF SAMPLE



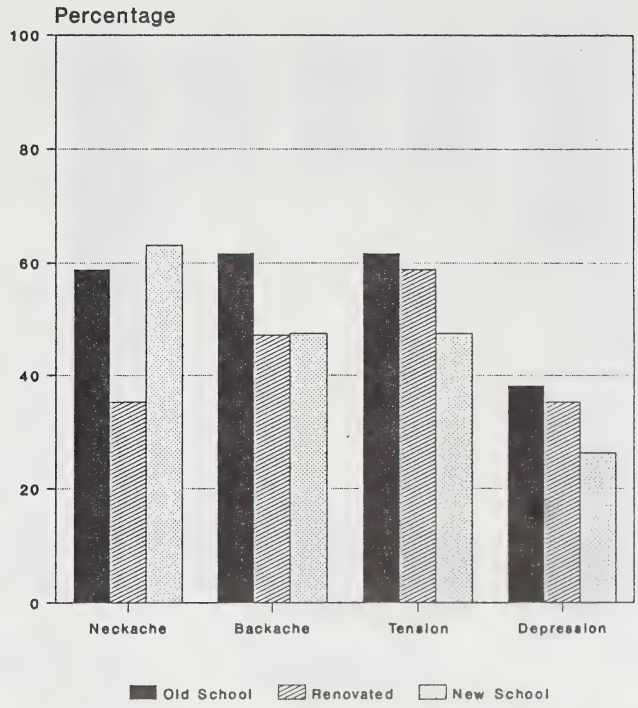
Graph No. 4

Work Environment Survey Results
NON AIR QUALITY RELATED QUESTIONS
AVERAGE OF SAMPLE



Graph No. 5

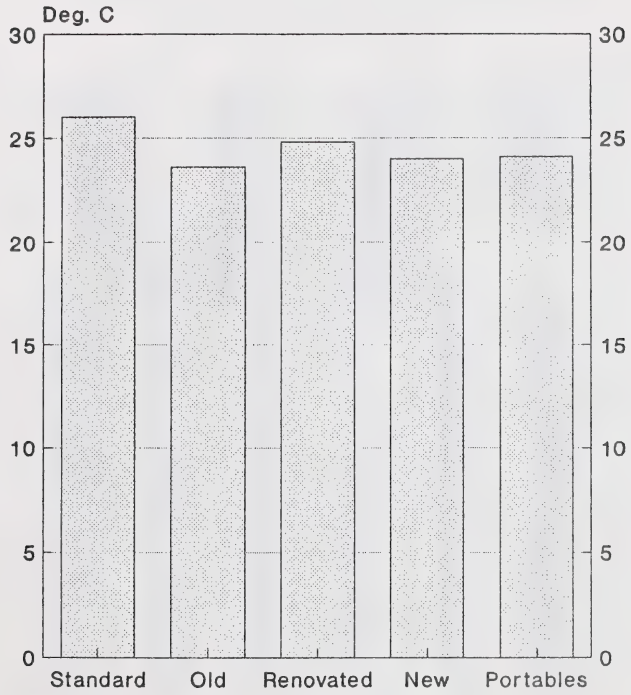
Work Environment Survey Results
NON AIR QUALITY RELATED QUESTIONS
SPECIFIC SCHOOL RESPONSES



Graph No. 6

Indoor Air Quality Measurements

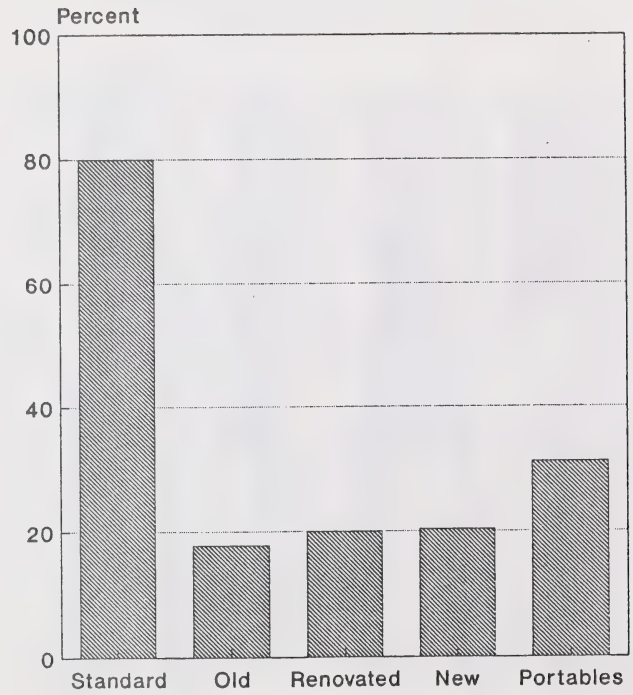
TEMPERATURE



Graph No. 7

Indoor Air Quality Measurements

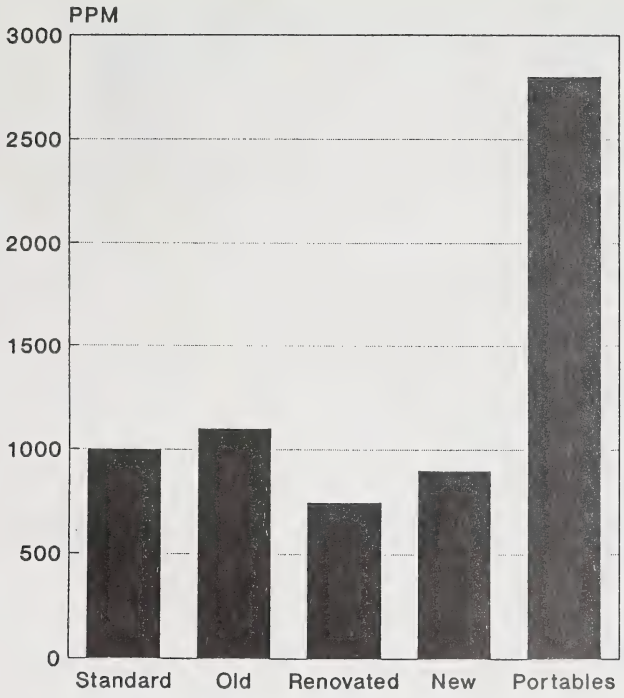
RELATIVE HUMIDITY



Graph No. 8

Indoor Air Quality Measurements

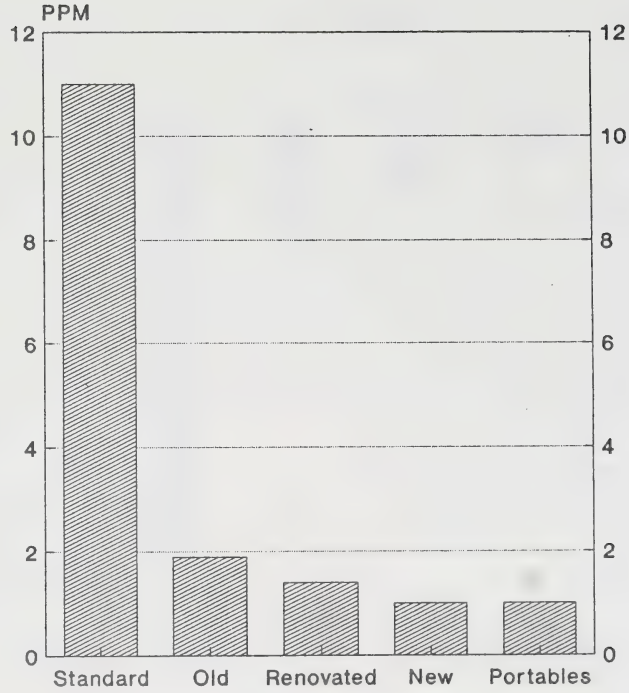
CARBON DIOXIDE (CO_2)



Graph No. 9

Indoor Air Quality Measurements

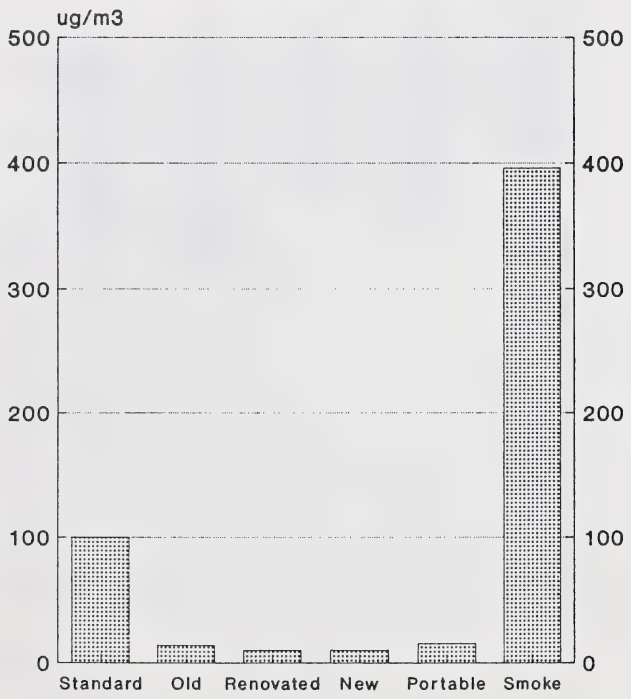
CARBON MONOXIDE (CO)



Graph No. 10

Indoor Air Quality Measurements

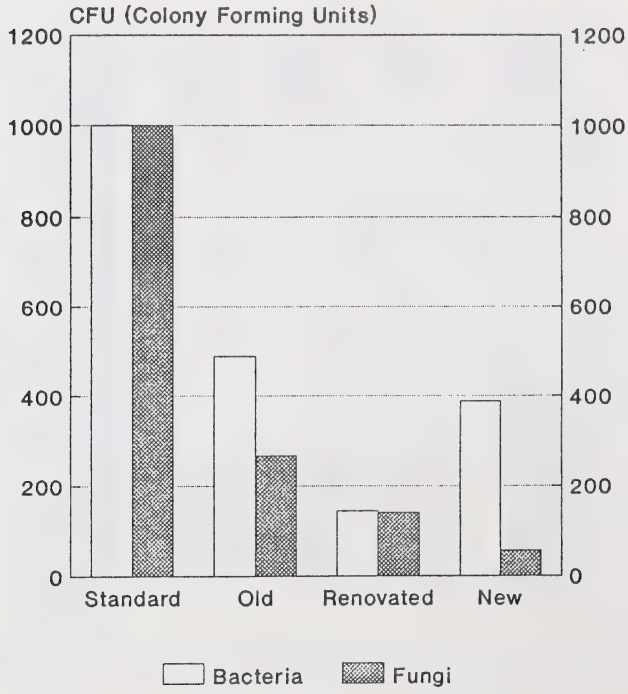
RESPIRABLE PARTICLES (RSP)



Graph No. 11

Indoor Air Quality Measurements

MICROBIOLOGICAL



Graph No. 12

APPENDIX C

WORK ENVIRONMENT SURVEY

OFFICE WORK ENVIRONMENT SURVEY

© TDS LIMITED, 70-1507 West 12th Ave., Vancouver, British Columbia, Canada V6J 2E2

This survey is being used to determine the quality of your work place. Your assistance in completing the following questions as accurately as possible is very much appreciated.

All information will be treated as confidential and anonymous.

FOR OFFICE USE ONLY

JOB	DEPT	BLDG	FLOOR
0 0	0 0	0 0	0 0
1 1	1 1	1 1	1 1
2 2	2 2	2 2	2 2
3 3	3 3	3 3	3 3
4 4	4 4	4 4	4 4
5 5	5 5	5 5	5 5
6 6	6 6	6 6	6 6
7 7	7 7	7 7	7 7
8 8	8 8	8 8	8 8
9 9	9 9	9 9	9 9
			G Ground
			B Basement

MARKING DIRECTIONS

- **DO NOT** staple or tape this sheet
- **DO NOT** make extraneous marks
- **USE** a soft lead pencil (e.g. HB)
- **FILL IN** the circle completely
- **ERASE COMPLETELY** any answer you wish to change

ALL RESPONDENTS PLEASE ANSWER THE FOLLOWING QUESTIONS

1. Date of Birth

MONTH	DAY	YEAR
Jan ○		
Feb ○		
Mar ○	0 0	0 0
Apr ○	1 1	1 1
May ○	2 2	2 2
Jun ○	3 3	3 3
Jul ○	4 4	4 4
Aug ○	5 5	5 5
Sep ○	6 6	6 6
Oct ○	7 7	7 7
Nov ○	8 8	8 8
Dec ○	9 9	9 9

2. Sex ○ Male ○ Female

3. Marital Status
- ○ Single
- ○ Married
- ○ Separated
- ○ Divorced
- ○ Widowed

4. Number of children
- ○ None
- ○ One
- ○ Two or more

5. Are you the primary source of income in your household?

○ Yes ○ No

6. Highest level of Educational Attainment (if applicable)
- ○ High School (non-graduate)
- ○ High School Graduation or equivalent
- ○ Technical Training
- ○ College Education
- ○ Undergraduate Degree
- ○ Postgraduate Degree

7. Please write within shaded area only.

JOB TYPE
DEPARTMENT
BUILDING FLOOR

8. Date of starting work in this building

MONTH	DAY	YEAR
Jan ○		
Feb ○		
Mar ○	0 0	0 0
Apr ○	1 1	1 1
May ○	2 2	2 2
Jun ○	3 3	3 3
Jul ○	4 4	4 4
Aug ○	5 5	5 5
Sep ○	6 6	6 6
Oct ○	7 7	7 7
Nov ○	8 8	8 8
Dec ○	9 9	9 9

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9. Employment Status

○ Full Time ○ Part Time ○ Temporary

10. On the average, how many hours a day are you in the building?

○ 1 to 4 ○ 5 to 8 ○ Over 8 hours

11. What time do you usually arrive at this building?

○ 9 a.m. or earlier
○ Between 9 a.m. and noon
○ Afternoon
○ Work night shift

12. What time do you usually leave this building?

○ 4 p.m. or earlier ○ After 4 p.m.

13. How many hours a week do you usually work in this building?

○ Under 25
○ 25 to 40
○ Over 40 hours

14. How many days have you been absent from work due to illness during the last six months?

○ None ○ 6 to 8
○ 1 to 2 ○ 9 to 12
○ 3 to 5 ○ Over 12 days

15. In the past six months, how many days have you left work earlier than you had planned due to feeling unwell?

○ None ○ 6 to 8
○ 1 to 2 ○ 9 to 12
○ 3 to 5 ○ Over 12 days

PLEASE RATE THE FOLLOWING QUESTIONS

	NEVER	RARELY	SOMETIMES	ALWAYS
16. In your job, are you able to make decisions on your own?	○	○	○	○
17. Are you free to organize how you do your job?	○	○	○	○
18. Can you control the speed at which you work?	○	○	○	○
19. Are you able to participate in decisions that affect your job?	○	○	○	○
20. Does your job require you to work very fast?	○	○	○	○
21. Does your job require a great deal of concentration?	○	○	○	○
22. Is your job boring or monotonous?	○	○	○	○
23. Is your job stressful?	○	○	○	○
24. Is your job satisfying?	○	○	○	○
25. Does your job require extensive physical exertion?	○	○	○	○
26. Does your job require you to use awkward movements or poor posture?	○	○	○	○
27. Are co-workers helpful in getting your job done?	○	○	○	○

PLEASE RATE THE FOLLOWING QUESTIONS

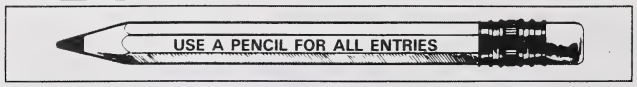
	NEVER	RARELY	SOMETIMES	ALWAYS
28. Do you find others frustrate your efforts to get your job done?	○	○	○	○
29. Are there enough staff in your department to cope with the work load?	○	○	○	○
30. Is your work area too crowded?	○	○	○	○
31. Do you remain in one location at work each day?	○	○	○	○
32. Does your job take you out of the building?	○	○	○	○
33. Do you leave the building at lunch time?	○	○	○	○
34. Do you find the building claustrophobic?	○	○	○	○

In your primary work area (that in which you spend the most time), how often did each of the following conditions occur in the last six months?

	NEVER	RARELY	SOMETIMES	ALWAYS
35. Too little air movement	○	○	○	○
36. Too much air movement	○	○	○	○
37. Just the right air movement	○	○	○	○
38. Air too dry	○	○	○	○
39. Air too moist	○	○	○	○
40. Humidity just right	○	○	○	○
41. Air too smokey	○	○	○	○
42. Air too stuffy	○	○	○	○
43. Unpleasant odours in the air	○	○	○	○
44. Temperature too hot	○	○	○	○
45. Temperature too cold	○	○	○	○
46. Temperature just right	○	○	○	○
47. Lighting too bright	○	○	○	○
48. Lighting too dim	○	○	○	○
49. Too much glare on work surface	○	○	○	○
50. Lighting just right	○	○	○	○
51. Too noisy	○	○	○	○
52. Too quiet	○	○	○	○
53. Noise level just right	○	○	○	○

How often do you use the following types of equipment at work?

	NEVER	RARELY	SOMETIMES	ALWAYS
54. Dictating machine	○	○	○	○
55. Typewriter	○	○	○	○
56. VDT/Word Processor	○	○	○	○
57. Photocopier	○	○	○	○
58. Duplicator	○	○	○	○
59. Adding machine or calculator	○	○	○	○
60. Microfiche	○	○	○	○



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If you work on a VDT/Word Processor please answer the following questions. If you do not, please skip this section and continue with Question 76.

How often are the following problems bothersome?

	NEVER	RARELY	SOMETIMES	ALWAYS
61. Flickering screen	○	○	○	○
62. Brightness of the screen	○	○	○	○
63. Contrast of the screen	○	○	○	○
64. Angle of the screen	○	○	○	○
65. Distance to the screen	○	○	○	○
66. Glare from lights above or behind the screen	○	○	○	○
67. Size of the lettering	○	○	○	○
68. Brightness of the lettering	○	○	○	○
69. Clarity of the lettering	○	○	○	○
70. Distance to the keyboard	○	○	○	○
71. Angle of the keyboard	○	○	○	○
72. Height of the desk	○	○	○	○
73. Seating comfort	○	○	○	○
74. Crowding of terminals	○	○	○	○

75. Are the keyboard and the screen separate units on the VDT/Word Processor at which you work?
○ Yes ○ No

ALL RESPONDENTS please continue with Question 76.

76. Do you find your chair comfortable?
○ Yes ○ No ○ Occasionally uncomfortable

Is your work area - *(Choose all that apply)*
77. ○ Enclosed by walls
78. ○ Enclosed by ceiling height partitions
79. ○ Enclosed by screens
80. ○ Partially enclosed by screens
81. ○ Not enclosed

82. Can you see a window from where you normally sit at work?
○ Yes ○ No

83. Do the windows open?
○ Yes ○ No ○ Yes, but not allowed

84. Approximately what distance are you from a window?
○ Less than 10 feet
○ 10 feet or more
○ No windows in the vicinity

How is your work area lit? *(Choose all that apply)*
85. ○ Fluorescent ceiling light
86. ○ Fluorescent table light
87. ○ Incandescent ceiling light
88. ○ Incandescent table light
89. ○ Natural window light

Are you able to control the following? *(Choose all that apply)*
90. ○ Work area temperature
91. ○ Work area ventilation
92. ○ Work area lighting
93. ○ Work area humidity

In the past year have any of the following been brought into your work area? *(Choose all that apply)*
94. ○ Portable heater
95. ○ Desk top fan
96. ○ Portable air cleaner
97. ○ Portable humidifier
98. ○ Negative ion generator
99. ○ Radio/Piped music

100. Do you smoke cigarettes?
○ Yes ○ No

101. Do you smoke cigars?
○ Yes ○ No

102. Do you smoke a pipe?
○ Yes ○ No

103. Do you smoke at work?
○ Yes ○ No

If you answered YES to Questions 100, 101, 102 or 103, please continue responding to the following questions. If you do not smoke, please continue with Question 107.

104. How many cigarettes do you smoke each day, on average?
○ None
○ 1 or less
○ 2 to 10
○ 11 to 20
○ 21 to 40
○ Over 40 cigarettes

105. How many cigars do you smoke each day, on average?
○ None
○ 1 or less
○ 2 to 4
○ Over 4 cigars

106. How many pipesful do you smoke each day, on average?
○ None
○ 1 or less
○ 2 to 5
○ Over 5 pipesful

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ALL RESPONDENTS please continue with Question 107.

107. Do you drink alcohol?
○ Yes ○ No

Do you wear any of the following corrective lenses at work? *(Choose all that apply)*
108. ○ No
109. ○ Reading glasses
110. ○ Regular glasses
111. ○ Bifocals
112. ○ Contact lenses

113. Do you work near people who smoke?
○ Yes ○ No

114. Does your workplace have a smoking policy?
○ Yes ○ No

If your workplace has a smoking policy, please answer the following questions. If not, continue with Question 122.

115. Which one of the following best describes the smoking policy at your workplace?
○ Smoking permitted at individual work stations
○ Office area divided into smoking and nonsmoking areas
○ Smoking in designated non-office areas only
○ Smoking totally prohibited

If smoking is restricted to designated areas, where are they located? *(Choose all that apply)*
116. ○ Cafeteria
117. ○ Coffee/Lunch room
118. ○ Smoking room not otherwise used
119. ○ Stairwells/Washrooms
120. ○ Other

121. How would you rate the air quality in the designated smoking areas?
○ Acceptable
○ Tolerable
○ Unacceptable
○ I do not use the designated areas

ALL RESPONDENTS please continue with Question 122.

122. Is your home air conditioned?
○ Yes ○ No

Which of the following cooking appliances do you use in your home? *(Choose all that apply)*
123. ○ Gas stove
124. ○ Electric stove
125. ○ Mixed gas and electric stove
126. ○ Microwave oven
127. ○ Other

What types of fuel are used to heat your home? *(Choose all that apply)*
128. ○ Gas
129. ○ Electricity
130. ○ Oil
131. ○ Coal
132. ○ Wood
133. ○ Kerosene/Paraffin
134. ○ Other

Have you experienced any of the symptoms listed below while at work in this building in the last six months?	NEVER	RARELY	SOMETIMES	ALWAYS
135. Headache	○	○	○	○
136. Fever	○	○	○	○
137. Dizziness	○	○	○	○
138. Fatigue	○	○	○	○
139. Sleepiness	○	○	○	○
140. Weakness	○	○	○	○
141. Nausea	○	○	○	○
142. Respiratory problems (breathlessness, wheezing)	○	○	○	○
143. Muscular aches in arms, hands, or wrists	○	○	○	○
144. Chest pain or tightness	○	○	○	○
145. Backache	○	○	○	○
146. Neckache	○	○	○	○
147. Eye irritation	○	○	○	○
148. Trouble focussing eyes	○	○	○	○
149. Sore or irritated throat	○	○	○	○
150. Nose irritation (itching or running)	○	○	○	○
151. Cold/Flu symptoms	○	○	○	○
152. Depression	○	○	○	○
153. Difficulty concentrating	○	○	○	○
154. Tension or nervousness	○	○	○	○
155. Skin dryness, rash or itching	○	○	○	○
156. Cold extremities (feet, hands, etc.)	○	○	○	○

157. Are you currently taking any courses of prescribed medication?
○ Yes ○ No

Do you suffer from any of the following?	YES	NO
158. Migraine	○	○
159. Asthma	○	○
160. Eczema	○	○
161. Hayfever or other allergies	○	○
162. Dysmenorrhea (painful menstruation)	○	○

THANK YOU FOR YOUR ASSISTANCE IN THIS SURVEY

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